

In the original account of *G. robustus* the position of the first nephridium was not fixed. The first pair seem to be in segment v. The segments in front of this are so filled up by the pharynx and associated glands that there would appear to be hardly room for a pair of nephridia. The median calciferous gland of this species was single, not paired as seems to be sometimes the case in the species.

The spermathecæ have an extraordinarily long duct, the length of which in relation to the pouch is inadequately represented in the figure illustrating it in the original memoir. It is no thicker than the sperm-duct and runs a straight course to its orifice.

3. Some Notes upon the Anatomy and Systematic Position of the Ciconiine Genus *Anastomus*. By FRANK E. BEDDARD, M.A., F.R.S., Prosector and Vice-Secretary of the Society.

[Received April 3, 1901.]

(Text-figures 89-91.)

Two out of the three examples of *Anastomus oscitans* acquired by the Society on Jan. 4th having died, I am able to contribute to our knowledge of the structure of the Order Herodiones by an account of certain points in the anatomy of this genus. So far as I am aware, *Anastomus* is one of the few genera of Storks which has not been dissected; and, as the genera of this order show some differences of structure, it is important to ascertain how *Anastomus* stands in relation to its allies. The chief sources of information as to the structure of the viscera and musculature of the Ciconiidae are those stated below¹.

These various memoirs and books contain information upon nearly all the genera of Storks; the only prominent genus which has not been treated of is that which forms the subject of the present communication. There has not been, so far as I am aware, any doubt as to the truly Stork-like characteristics of *Anastomus*.

¹ GARROD, "On the Carotid Arteries of Birds," P. Z. S. 1873, p. 457; id., "On certain Muscles of the Thigh of Birds, &c.," *ibid.* 1873, p. 626; id., "On the Form of the Trachea in certain Species of Storks and Spoonbills," *ibid.* 1875, p. 297; id., "Note on an Anatomical Peculiarity in certain Storks," *ibid.* 1877, p. 711; id., "On the Trachea of *Tantalus loculator*, &c.," *ibid.* 1878, p. 625.

WELDON, "On the Anatomy of *Phenicopterus* and its Allies," P. Z. S. 1883, p. 638.

FÜRBRINGER, Untersuchungen über Morphologie und Systematik der Vögel, Amsterdam, 1888, *passim*.

BEDDARD, "A Contribution to the Anatomy of *Scopus umbretta*," P. Z. S. 1884, p. 543; id., "On certain Points in the Visceral Anatomy of *Baleniceps rex*," *ibid.* 1888, p. 284; id., "Notes on ... the Syrinx in certain Storks," *ibid.* 1886, p. 321; id., "A Note upon *Dissura episcopus*, with Remarks upon the Classification of the Herodiones," *ibid.* 1896, p. 231; id., The Structure and Classification of Birds, London, 1898.

GADOW, "Aves" in Bronn's Klassen und Ordnungen des Thier-Reichs,

It has, however, been placed in a subfamily—and even in a family!—by itself, contrasting with the remaining genera, *Ciconia*, *Mycteria*, *Xenorhynchus*, &c. I find no sanction for this separation of *Anastomus* after an examination of its structure, unless, indeed, the peculiar formation of the quadrate bone, to which I shall refer later, is considered to necessitate so wide a divorce from other typical Storks. The viscera, muscles, and the skeleton in general, conform to the Ciconiine plan in every particular. And for my part I am disposed to regard *Xenorhynchus*, *Dissura* (*episcopus*), and *Abdimia* as more anomalous Storks than is *Anastomus*. The peculiar fringing of the bill in *Anastomus lamelligerus* is perhaps responsible for this separation of the genus from its allies. But lamellæ of a similar character are found in *Phœnicopterus*, which is in my opinion to be clearly regarded as a Stork. Moreover, they do not exist at all in the species which forms the subject of the present communication. The muscle-formula of the thigh is the typically Ciconiine one; no muscles are missing as is the case with *Abdimia*, *Xenorhynchus* (in part), on the one hand, or in *Leptoptilus* on the other; while the syrinx, so characteristic an organ in the Stork tribe, though peculiar in some respects—as I shall explain immediately—is constructed upon the Ciconiine plan, and does not diverge towards the Ardeine syrinx, as do those of *Scopus*, *Baleniceps*, and—to a less extent—*Xenorhynchus*, *Abdimia*, and *Dissura*. The skeleton, moreover, with the exception of the quadrate, is quite that of a Stork in every respect, though naturally details permit of a definition of this genus *Anastomus*.

Anastomus differs from some Storks in possessing no aftershaft. The rectrices, in the present specimen, although several are missing, appear to have been 12. The oil-gland is of course tufted.

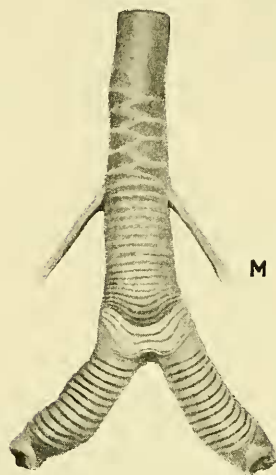
The alimentary viscera appear to be quite Stork-like. The two lobes of the liver are subequal as usual. The small intestine is particularly long; it measured 7 feet 8 inches, the large intestine being only 3 inches and the cæca mere “nipples.” As a rule the intestinal canal in Storks appears to be shorter.

The windpipe (text-figs. 89, 90, p. 367) is also quite Stork-like. The last 13 tracheal rings in front of the pessulus are short and delicate, and form as in other Storks a definite area of the trachea. The pessulus itself is ossified; with it are fused four rings as on the ventral side, but only two on the dorsal. There is no trace whatsoever of a *membrana tympaniformis*. The bronchial rings are thus complete, and beginning with the last, which is connected with the syringeal box (on the ventral side), are partly ossified.

As regards the muscular anatomy, I have paid special attention to those muscles which differ among the Herodiones.

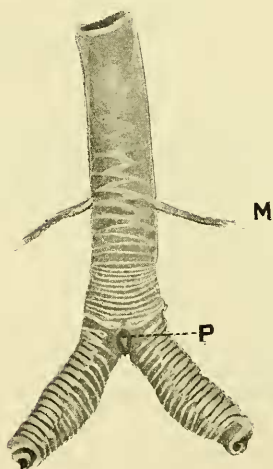
Tensores patagii.—The tensor brevis is quite Stork-like in the arrangement of its tendons. The tendon is flat and broad with a thickened anterior part; the contrast between this and the rest of the tendon dies away as the tendon approaches its insertion. It bifurcates, as usual, into a double tendon a little before insertion.

Text-fig. 89.

Syrinx of *Anastomus oscitans*, front view. $\times 1$.

M, Extrinsic muscle.

Text-fig. 90.

Syrinx of *Anastomus oscitans*, back view. $\times 1$.

M, extrinsic muscle P, pessulus.

There are two recurrent tendinous slips to the tensor patagii longus tendon. One of these, the thinner and broader, arises from the anterior tendon of the brevis; the other, which runs almost parallel with it, arises close to the insertion of the tensor brevis, but distinctly from an extensor tendon of the forearm. In *Ciconia nigra*¹, *Mycteria americana*², and *Tantalus leucocephalus* there is only a single recurrent slip, which, however, in *Ciconia*, branches into a double insertion. There is, as is the case with other Storks, no biceps slip.

The two *latissimi dorsi* are fairly equal in size; the anterior has a completely fleshy insertion; the posterior division is flat and strap-like, as is the anterior, but ends abruptly in two tendons of comparatively insignificant dimensions. One of these, the stronger, is insertated on to the humerus, headwards of but beside the tendon of the anconeus. The other is inserted on to the tendinous belly of the same muscle. This appears to be the usual insertion in Storks and in the Flamingo, but not in *Scopus*.

The *deltoides major* has the long second tendinous head from the scapula that is common if not universal in Storks. The main scapular head is, however, fleshy. The scapular tendon arises from the dorsal side of the scapula, and if the origin of the anconeus from the ventral border of the scapula were continued forwards it would meet that head.

The *anconeus longus* has two plainly separate heads of origin which are both tendinous. One has been just referred to. The other is thicker and arises from the scapula nearer to the coracoid. A broad and thin tendon attaches this muscle to the humerus in the ordinary way.

The *serratus superficialis posterior* is wide and thin, and largely tendinous; it is attached to the posterior two-thirds of the scapula. It arises from the uncinate process of rib 1 to that of rib 3.

The *serratus superficialis anterior* is a thick fleshy muscle attached to the scapula near to the coracoid end; it arises from the first complete rib, and a considerable gap is left between its insertion and that of the superficialis posterior. It may be noted that the muscle arises only from its rib, and not also from a cervical rib as in some other Storks.

The *pars metapatagialis* is strong.

The *serratus profundus* (*levator scapulae* of Weldon) consists of only two slips, neither of which are of large size. They arise respectively from the last cervical and the first dorsal rib.

The *biceps* is two-headed as in other Storks.

The *expansor secundariorum* is present and attached to the margin of the *teres*.

The thigh-muscles of *Anastomus* are quite typically Stork-like, the formula being $AXY+$, the complete one for a Stork³. The

¹ Fürbringer, Unters. Morph. Syst. Vögel, pl. xx. fig. 7.

² Forbes MS.

³ There is a feeble accessory femoro-caudal in *Xenorhynchus australis*.

ambiens is rather small, as in *Xenorhynchus australis* (it is of course absent in *X. senegalensis*), but plainly obvious.

The *semitendinosus* is smaller than the semimembranosus. It ends in the septum between itself and its accessory and in a thin tendon which joins the broad flat tendon of the semimembranosus.

The *femoro-caudal* is of fair size and has a fleshy insertion; there were no traces of its accessory.

The *gluteus maximus* is mainly tendinous; its origin hardly, if at all, extends behind the acetabulum. I find *four* other *glutei*¹, of which *tertius* and *quartus* are inserted so near together as to appear at first sight but a single muscle. A little care, however, shows them to be distinct.

The two *adductors* are separated at their insertion, one being attached as usual with the femoral head of the accessory semitendinosus.

There is only one *peroneus*, the *p. brevis* being absent.

The *gastrocnemius* has three heads and is joined by the accessory semitendinosus.

The deep flexor tendons have the Ciconiine arrangement, a strong vinculum joining the flexor hallucis to the flexor communis just before the trifurcation of the latter.

Skull.—Judging from the measurements giving by Dr. Blanford², the skull of my example of *Anastomus oscitans* is about two-thirds of the size to which it would ultimately have grown. It therefore shows certain but not very numerous signs of immaturity³. I have been able, however, through the kindness of Mr. Gerrard, to compare it with the skull of an older example of *Anastomus lamelligerus*. The principal specific difference which I observed was the greater length of the beak-region of the skull in *A. lamelligerus* as compared with other Storks. *Anastomus* shows some peculiarities of skull-structure.

I could find no trace of a vomer in either specimen, a bone which, though small, is usually recognizable in Storks.

The pterygoids are unusually short and very broadly expanded where they come into relation with the palatines. This character of the skull of *Anastomus* is shown in the accompanying drawing (text-fig. 91, p. 370). The most salient difference, however, observable in this aspect of the skull is the form of the quadrate, that is of its articular surface for the attachment of the lower jaw. It will be noted that in *Anastomus* the quadrate has two facets—one longer saddle-shaped facet at right angles to the longitudinal axis of the skull; the other shorter at the jugal end of the under surface of the bone, much shorter than the first and more or less at right angles to it. The articular surface of the quadrate is therefore very narrow, and in this contrasts with the genera *Ciconia*, *Tantalus*, *Xenorhynchus*, and *Dissura*. In all these genera the lower articular surface of the quadrate is very broad, and the two main facets are

¹ Weldon only found three in the Storks dissected by himself.

² The Fauna of British India, Birds, vol. ii. p. 378.

³ It is, for instance "schizognathous."

roughly of equal dimensions and parallel to each other, the posterior facet curving forwards in a hook-like fashion at the jugal side of the bone. It is this curved and forwardly directed portion of the facet which alone represents the second smaller facet of the quadrate of *Anastomus*. This peculiarity of *Anastomus* does not, I may remark, link it to the *Heronis*; but, though there are detailed differences, the quadrate of *Platalea* has a small corresponding articular surface.

Text-fig. 91.



A, skull of *Anastomus oscitans*, ventral aspect, $\times 1$. B, quadrate and adjoining bones of *Ciconia nigra*.

a, b, facets on quadrate.

When the skull is viewed laterally, the angle which the facial portion makes with the cranial is very noticeable and not Stork-like. This feature coupled with the curved lower jaw is not

unsuggestive of the Flamingo. It may be noted that the post-frontal process and the process of the squamosal are far from each other as in most Storks: in *Xenorhynchus* these two processes join.

In other respects the skull of *Anastomus oscitans* appears to me to be quite Stork-like.

Vertebrae.—There are 17 cervical vertebræ as against 18 in *Xenorhynchus* and *Tantalus*. All Storks that I have examined, except *Anastomus* and *Dissura*, possess a catapophysial canal occupying a varying number of vertebræ. In not having this canal *Anastomus* agrees with *Phœnicopterus* among possible allies.

Ribs.—There are 5 fully developed pairs of ribs, which reach the sternum, and of which the first four are provided with uncinat processes. The origins of the last two are overlapped to the pelvis. In front of the series of complete ribs are two rudimentary ribs, of which the first pair are as usual exceedingly small. The vertebra in front of that which bears the latter has very delicate and thus rib-like transverse processes; but they are firmly ankylosed to the vertebra. On the left-hand side of the body a minute fragment represents a posterior pair of ribs.

The rib-formula of *Anastomus* may be thus stated and compared with some other Storks:—

Anastomus: $r + r' + 5 + r$.

Xenorhynchus australis: $r + r' + R + 4$.

„ *senegalensis*: $r + r' + R + 4 + r'$.

Tantalus leucocephalus: $r + r' + 5$.

Dissura maguari has five complete ribs.

The coracoids of *Anastomus* just overlap at their insertion on to the sternum. Storks differ in this feature; while *Tantalus* agrees with *Anastomus*, the coracoids of *Xenorhynchus* and *Dissura* do not even meet.

A final point in the osteology of *Anastomus* to which I desire to direct attention is the proportion of the metatarsals, which are not identical in all these long-legged birds. In the subject of the present communication the second and third metatarsals are nearly of the same length, the middle one being slightly longer as well as slightly thicker.

In *Tantalus* the middle metacarpal is very decidedly the longer, and the fourth is even slightly longer than the second.

Ardea has a foot which has diverged in the opposite direction. The second metatarsal is distinctly the longest, and the fourth is much shorter than the third.

Phœnicopterus agrees with *Tantalus* in the excess of the middle metatarsal, but the fourth is the shortest.